NATIONAL BUREAU OF STANDARDS REPORT

6875

PERFORMANCE TEST OF AN ELECTRO-AIR
ELECTROSTATIC AIR CLEANER, MODEL 20-1

by

Carl W. Coblentz and Paul R. Achenbach

Report to

General Services Administration
Public Buildings Service
Washington 25, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Building Technology Division

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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of an Electro-Air electrostatic air cleaner were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air and of Cottrell precipitate, the pressure drop, and the dust holding capacity of the specimen.

2. DESCRIPTION OF TEST SPECIMEN

The air cleaner was manufactured and supplied for test purposes by the Electro-Air Cleaner Company of McKees Rocks, Penna., and was designated as Model 20-1.

The collector cell assembly was 23 13/16" high and 19 1/2" wide, presenting a gross face area of 3.23 sq ft. The frame of the cell as well as the 29 charged and 28 grounded plates were made of aluminum. The plates were spaced 5/16" center to center and measured 10 3/4" x 23". Each plate was 0.020" thick and had two V-shaped reinforcing crimps. There were 11 ionization wires separated by elongated pear-shaped separators. The cell was equipped with an after-filter, type Airsan AF 150, 18 1/4" x 22" x 1". Before installation into the test apparatus, the cell was sprayed with an adhesive, type DAX, furnished by the manufacturer.

The power pack was designed to supply a potential of 8.2 KV to both ionizer wires and collector plates. Two 200-watt light bulbs in series with the primary transformer winding functioned as a ballast when the plate current increased during plate discharges. Overload protection for the power pack was provided by a 2.4 amp breaker switch and a 2 amp fuse. The actual line current could be observed on an ammeter with a range of 0-2 amperes. The adjustment of the electrostatic potential was accomplished with a rheostat in the primary of the transformer.

The high voltage output of the transformer was rectified with a full-wave selenium rectifier which was shunted by a bleeding resistor to prevent shock from residual energy.

3. TEST METHOD AND PROCEDURE

The arrestance measurements were made in accordance with the "NBS Dust Spot Method" described in a paper by R. S. Dill and entitled "A Test Method for Air Filters," (ASHVE Transactions, Vol. 44, p. 379, 1938).

For test purposes, the collector cell was installed in the test apparatus and carefully sealed to prevent inward leakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct two feet upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The change of the opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean.

For determining the arrestance of the filter, with Cottrell precipitate as the test dust, different size areas of sampling papers were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers. The arrestance, A (in percent), was then calculated by the formula:

$$A = \left(1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U}\right) \times 100$$

where S_U and S_D are the upstream and downstream sampling areas and ΔU and ΔD the observed changes in the opacity of the upstream and downstream sampling papers, respectively.

For determining the arrestance of the particulate matter in the laboratory air, equal sampling areas were used for the upstream and downstream samplers. A similar increase of the opacity of the upstream and downstream filter papers was then obtained by passing the sampling air through the upstream paper

only part of the time while operating the downstream sampler continuously. This was accomplished by installing one solenoid valve in the upstream sampling line and another one as a by-pass. The valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the following formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD being the changes of opacity of the sampling papers, as previously indicated.

The power pack was connected to the laboratory electric line through a variable voltage transformer. The rheostat of the power pack was adjusted so that the energizing voltage was 8.2 KV at 117 volts input. The rheostat setting was not changed during the test and the plate potential was measured with an electrostatic kilovoltmeter at an input voltage of 117 ± 1/4 volts.

The tests were attended by two representatives of the manufacturer, who suggested minor modifications to the arrangements of the collector cell in the test apparatus after observing that the arrestance values at various air flow rates were considerably lower than had been expected. When no improvement of the arrestance was observed, it was agreed that an earlier model of the test specimen would be retested to ascertain whether there was any discrepancy in the test procedure or a malfunction of the test apparatus. This older cell had been tested at the NBS in 1957 and had at that time an arrestance of 91.2% using a 2" thick after-filter. When it was now tested with a 1" thick after filter, the arrestance was 90.5%. This was accepted by the manufacturer's representatives as evidence that the apparatus was functioning satisfactorily.

A total of twenty arrestance determinations were made using either the particulate matter of the laboratory air or Cottrell precipitate as the aerosol. After making two arrestance determinations, each at the rated air flow rate of 1650 cfm (510 ft/min gross face velocity) and at 20 percent below and above this

air flow rate, the filter was loaded with Cottrell precipitate and lint to a dust load of about 2/3 grams per cfm rated flow rate, i.e. 1095 grams. A number of arrestance determinations were made at selected intervals while the device was being loaded and a final determination was made at the end of the test.

4. TEST RESULTS

A summary of the test results is presented in Table 1, which shows the air flow rates, cumulative dust loads, plate and ionizer voltages and the supply current of the power pack, the combined pressure drop across the collector cell and after filter and the arrestance values determined with Cottrell precipitate and with the particulate matter in the laboratory air.

The effect of the dust load on the pressure drop and on the arrestance are plotted in Fig. 1; the effect of the air flow rate on the arrestance of the filter before loading is plotted in Fig. 2.

The pressure drop across the device increased from 0.307 in. W.G. to 1.11 in. W.G. as the filter was being loaded to a final value of 1095 grams/sq ft of Cottrell precipitate and lint, corresponding to 2/3 grams per cfm rated air flow. During this time the arrestance of atmospheric air borne dust decreased approximately linearly from 88.8 percent to 84.2 percent, whereas the arrestance of Cottrell precipitate decreased from 98.0 percent to 97.1 percent.

The arrestance of the particulate matter in the laboratory air at 1320 cfm air flow rate was 92.4 percent and at 1980 cfm 84.8 percent. These flow rates are 20 percent below and above the rated 1650 cfm.

An examination of the collector cell after the conclusion of the test showed that all plates were evenly covered with a light layer of dust. However, there was a large number of bridges up to about 3/8 in. wide between the plates, apparently formed by lint particles. These bridges were especially numerous near the downstream sides of the collector plates. Practically no bridges were found in the first two inches at the inlet end of the collector cells. As many as 22 bridges were counted between two adjacent plates.

Table 1

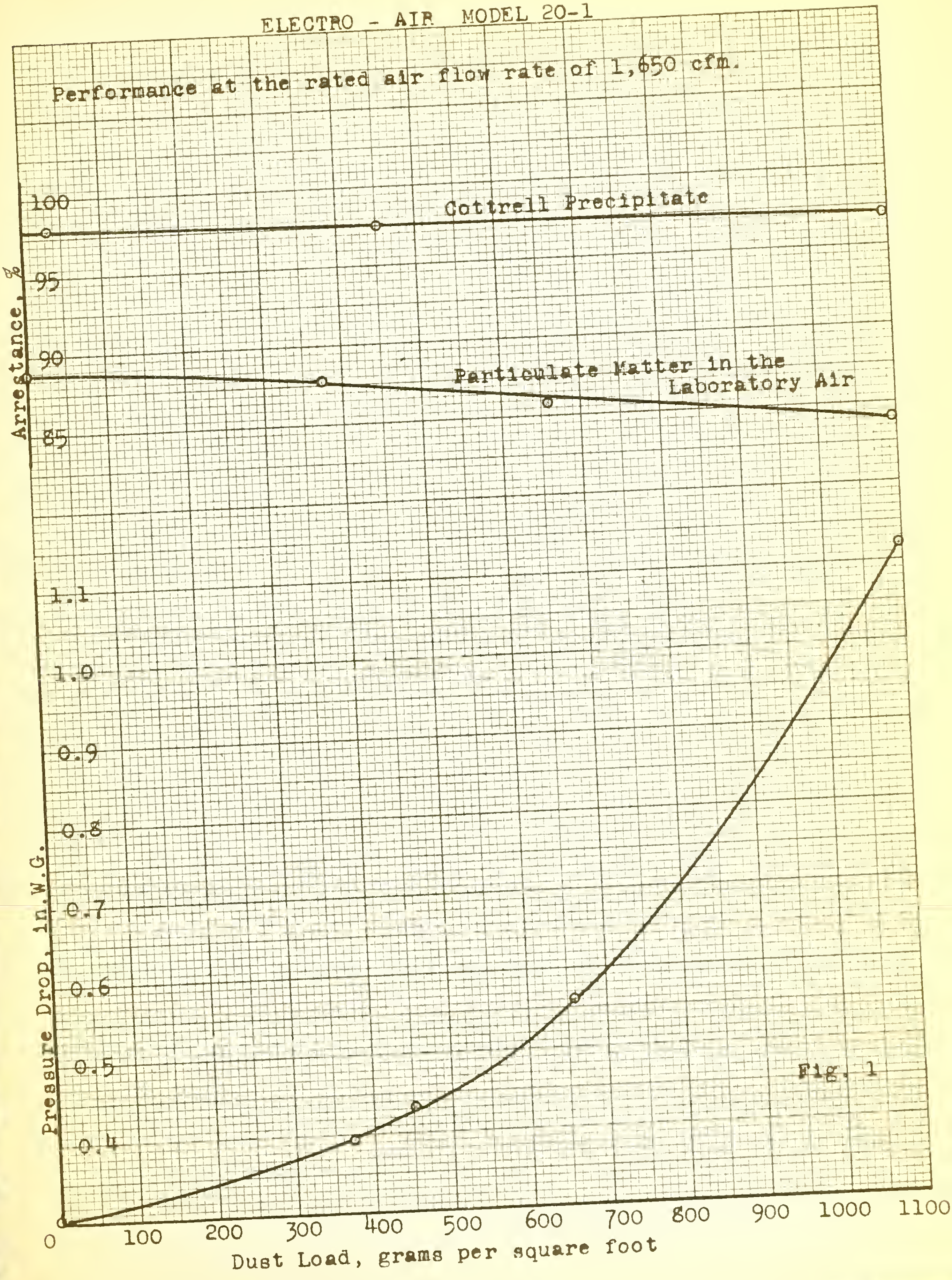
Performance of Electro-Air, Model 20-1
(Gross Face Area 3.23 sq ft)

Air Flow Rate cfm	Dust Load g	Ionizer and Plate Voltage KV	Current amp	Pressure Drop in. W.G.	Arrestance %	Aerosol Used **
1320	0	8.2	0.55	0.205	92.4*	A
1650	0	8.2	0.55	0.307	88.8*	A
1980	0	8.2	0.55	0.436	84.8*	A
1650	32	8.2	0.60	0.308	98.0*	B
1650	373	8.2	0.60	0.394	87.8	A
1650	452	7.9	0.65	0.432	97.6*	B
1650	659	7.8	0.65	0.559	85.8	A
1650	1095	7.7	0.65	1.11	97.1*	B
1650	1095	8.2	0.63	1.13	84.2	A

* Average of two or more tests.

** A - Particulate matter in laboratory air.

B - Cottrell precipitate in laboratory air.



ELECTRO - AIR MODEL 20-1
Performance at the rated air flow rate of 1,650 cfm.
Cottrell Precipitate
Particulate Matter in the Laboratory Air
Arrestance, %
100
95
90
85
Pressure Drop, in. W.G.
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0
100
200
300
400
500
600
700
800
900
1000
1100
Dust Load, grams per square foot

Fig. 1

ELECTRO - AIR Model 20-1

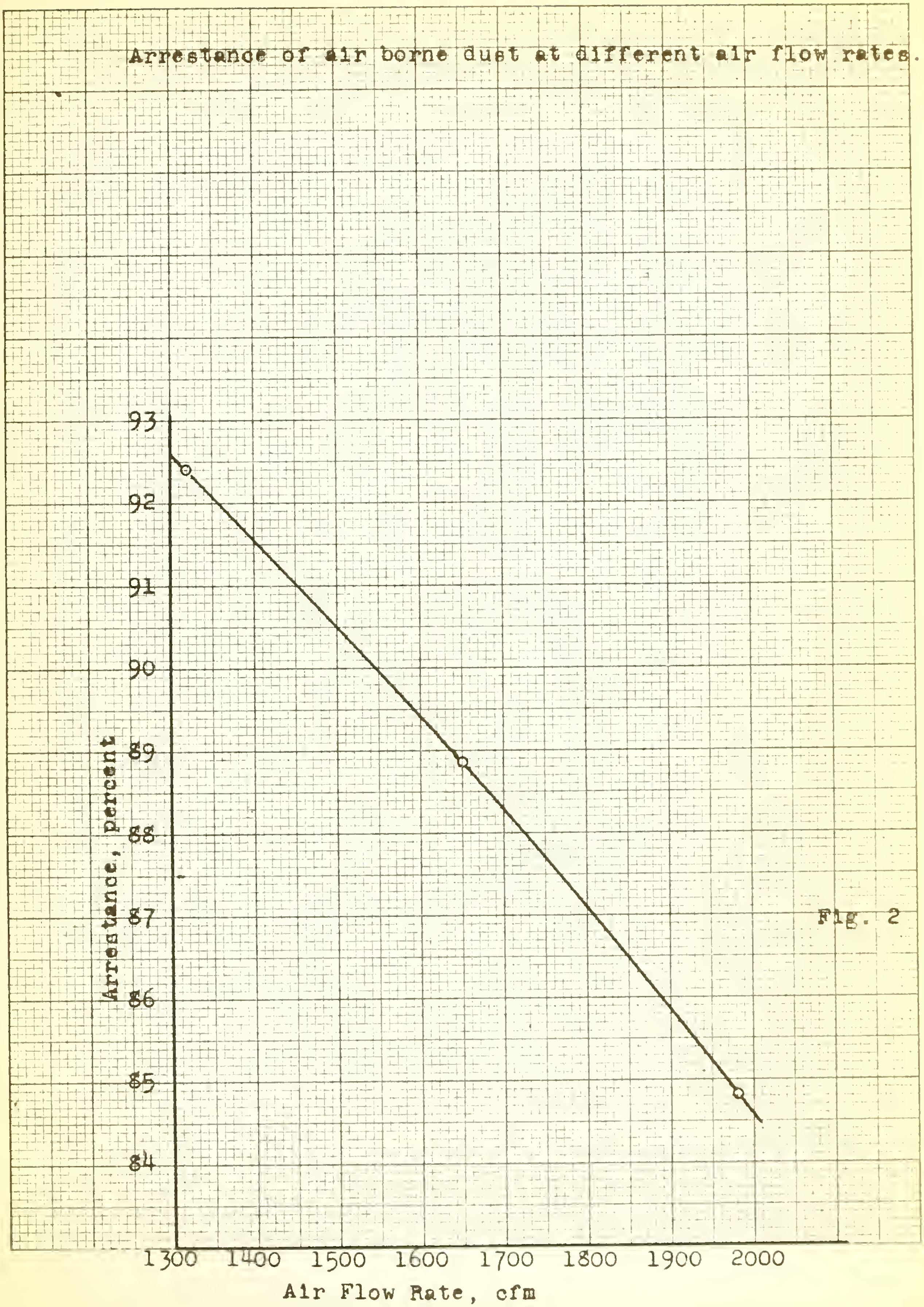


Fig. 2

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THE NATIONAL BUREAU OF STANDARDS

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Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation. • Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

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